Teton River Subbasin Assessment And Total Maximum Daily Load


Photo courtesy of Timothy Randle, Bureau of Reclamation

Department of Environmental Quality

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The cooperation of the landowners along the North Fork Teton River made it possible to conduct an inventory of the entirety of that river.

Many individuals at the Department of Environmental Quality assisted in preparing this report. Sheryl Hill gathered and complied data and drafted much of the document; Mark Shumar, Marti Bridges, and Amy Luft revised and completed the final version of the report; Dinah Reaney, Darcy Sharp, Mark Shumar, and Don Zaroban provided technical assistance; and Troy Saffle, Derek Young, Jim Szpara, Kimberly Ball, and Tammy Gallion provided additional assistance in the preparation of this document.

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

303(d) Refers to section 303, subsection (d) of the Clean Water Act, or a list of impaired waterbodies required by this section

ì micro, one-one millionth

§ Section (usually a section of federal or state rules or statutes)

BLM United States Bureau of Land Management

BOD biological oxygen demand

BOR United States Bureau of Reclamation

BURP Beneficial Use Reconnaissance Program

C Celsius

CFR Code of Federal Regulations (refers to citations in the federal administrative rules)

cfs cubic feet per second

cm centimeters

CWA Clean Water Act

DEQ Department of Environmental Quality

EPA United States Environmental Protection Agency

EPT insects of the orders Ephemeroptera, Plecoptera, and Trichoptera

F Fahrenheit

FERC Federal Energy Regulatory Commission

FMID Freemont Madison Irrigation District

FRREC Fall River Rural Electric Cooperative

FTU formazin turbidity unit

GIS Geographical Information Systems

HI habitat index

HUC Hydrologic Unit Code

IDAPA Refers to citations of Idaho administrative rules

IDFG Idaho Department of Fish and Game

IDWR Idaho Department of Water Resources

INEEL Idaho National Engineering and Environmenal Laboratory

IWRB Idaho Water Resources Board

JTU Jackson turbidity unit

km kilometer

m meter

MBI macroinvertebrate index

MGD million gallons per day

mg/L milligrams per liter

mm millimeter

MSWCD Madison Soil and Water Conservation District

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

NTU nephelometric turbidity unit

NWS National Weather Service

RMP resource management plan

SAWQP State Agriculture Water Quality Project

SCC Idaho Soil Conservation Commission

SNOTEL Snow telemetry

STATSGO State Soil Geographic Database

TKN Total Kjeldahl nitrogen

TN total nitrogen

TMDL total maximum daily load

TSCD Teton Soil Conservation District

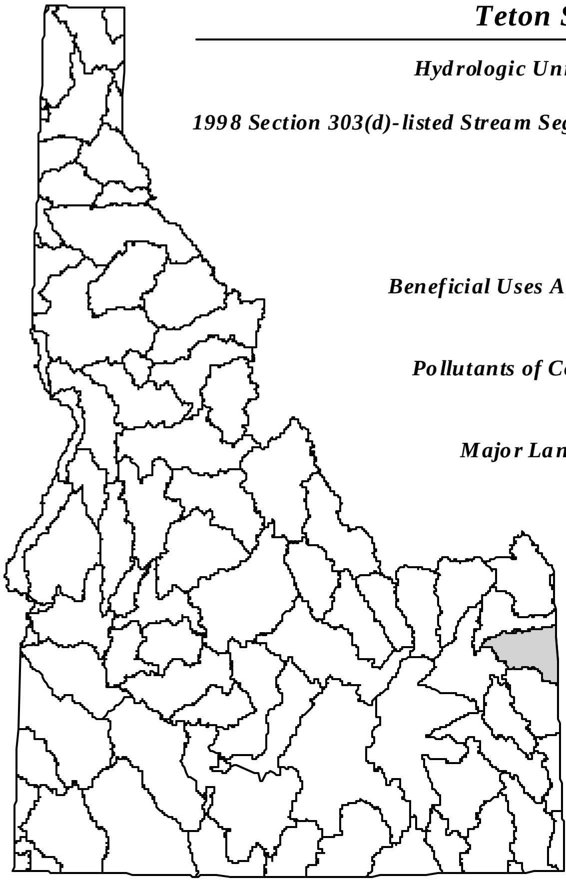
TSS total suspended solids

USDA United States Department of Agriculture

USFWS United States Fish and Wildlife Service

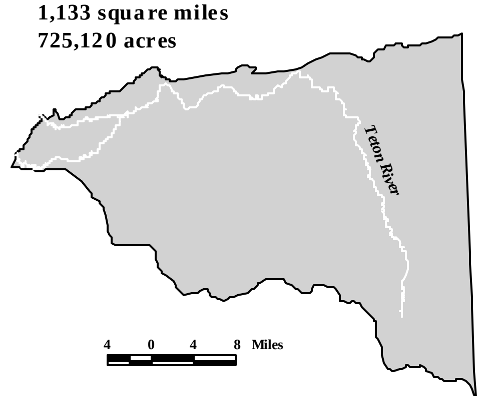
USGS United States Geological Survey

WQLS water quality limited segment



Teton Subbasin at a Glance

Hydrologic Unit Code	**17040204**
1998 Section 303(d)-listed Stream Segments	**Badger, Darby, Fox, Horseshoe, Moody, North Leigh, Packsaddle, South Leigh, and Spring Creeks; Teton River from headwaters to Bitch Creek; North Fork Teton River**
Beneficial Uses Affected	**Cold Water Aquatic Life Salmonid Spawning**
Pollutants of Concern	**Sediment, Nutrients, Temperature Flow Alteration, Habitat Modification**
Major Land Uses	**Agriculture, Recreation**
Area	**1,133 square miles 725,120 acres**



EXECUTIVE SUMMARY

The Teton Subbasin is one of three watersheds that comprise the Henry's Fork Basin. The Teton River drains an area of 806 square miles in Idaho and 327 square miles in Wyoming. The river originates from headwater streams in the Teton, Big Hole, and Snake River mountain ranges and flows more than 64 miles to the point at which it discharges to the Henry's Fork River. Twenty river miles southwest of this point, the Henry's Fork joins the South Fork Snake River to form the mainstem of the Snake River.

The Teton Subbasin is physically and biologically diverse. Elevations range from almost 11,000 feet along the eastern edge of the subbasin to approximately 4,800 feet in the Henry's Fork floodplain of the western subbasin. The eastern portion of the subbasin lies within the Middle Rocky Mountain physiographic province, the western portion lies within the Snake River Plain physiographic subprovince, and the south central portion lies within the Basin and Range physiographic province. Natural vegetation includes Douglas fir, western spruce-fir, lodgepole pine, and alpine meadow plant communities at higher elevations, and sagebrush steppe and saltbrush/greasewood communities at lower elevations. A defining feature of the Teton Subbasin is the extensive wetland complex associated with the upper Teton River. Climate varies within the subbasin according to elevation, but is generally characterized by cold winters, with average minimum daily temperatures of less than 10 ^{o}F in January, and mild summers, with average maximum daily temperatures of less than 85 ^{o}F in July. The annual precipitation averages less than 16 inches and the growing season is short, with less than 82 days exceeding a temperature of 32 ^{o}F in nine years out of ten. The average total precipitation is greatest in May and June, and average total snowfall is greatest in December and January. The average annual snowfall at Driggs, in the upper subbasin, is 65 inches.

Three distinct reaches of the Teton River have been defined by the geologic and topographic features of the subbasin. The river takes form at the southern end of the first reach, which is a structural basin referred to as Teton Valley or Teton Basin. This basin is approximately five miles wide and 20 miles long, and was at one time blocked at its northern end by volcanic deposits. The lake-type depositional area filled with fine-sized debris washed from the alluvial fans that formed at the base of the Teton Range. This produced soils that are poorly drained organic-rich silty clay loams and gravelly loams underlain by a relatively impervious layer of clay. Now, as streams flow out of the Teton Range, water subsides into the coarse-sized, well-drained alluvium along the eastern edge of the basin. The water percolates through the soil until it reaches the impervious layer, then apparently flows along this surface until it re-emerges as springs and seeps approximately two-to-three miles west of the point at which it subsided. These conditions create the wetlands of the Teton Valley. The second reach of the Teton River includes the canyon that it carved through the felsic and basaltic volcanic deposits of the subbasin. At its confluence with Bitch Creek, a major tributary, the river makes an almost 90^{o} turn to the west. Teton Canyon, with steep walls rising as high as 500 feet, contains the river for approximately 17 miles. In 1975, Teton Dam was completed at the lower end of the canyon to create a reservoir for irrigation water. In June 1976, when the reservoir behind the dam had almost filled, the earthen dam collapsed. More than 250,000 acre-feet of water and four million cubic yards of embankment material flowed through the breach in less than six hours. Reconstruction of the dam was not attempted, and the United States Bureau of Reclamation recently studied the effects of the dam collapse on the river channel and canyon in an effort to determine future management of the area. The third reach of the river extends from the Teton dam site to the Henry's Fork, and includes the floodplains of the North and South Forks of the Teton River and the Henry's Fork River. This reach was extensively altered by the flood that followed the collapse of the Teton Dam, and by the mitigation and restoration work that followed the flood.

Stream discharges in the Teton Subbasin are generally a function of snowmelt runoff. Peak discharges occur in May or June when average total precipitation reaches a maximum and warmer average daily temperatures accelerate the rate of snowmelt. In the upper subbasin, two periods of peak flow are associated with two distinct snowmelt periods. The first occurs when snow at lower elevations melts in March and April; the second occurs when snow at higher elevations melts in late May and June, and is accompanied by rainfall. Many of the streams that originate in the Teton and Big Hole mountain ranges do not connect to the Teton River except during periods of peak flow.

Approximately 75% of land in the Teton Subbasin west of the Idaho-Wyoming border is privately owned, and the principal land use is cultivated agriculture. The eastern portion of Teton Subbasin is located in Teton County, Wyoming, and Teton County, Idaho; the western half of the subbasin is located primarily in Madison County. According to the 1997 National Census of Agriculture, approximately 78,000 cropland acres were harvested in Teton County, Idaho, and 149,000 cropland acres were harvested in Madison County. Almost 74% of the harvested acres in Teton County and 86% of the harvested acres in Madison County were irrigated. Major crops were barley, wheat, hay, and potatoes. In terms of livestock production, the inventory of beef and dairy cattle was at least ten times the inventory of hogs, sheep, and poultry, with each county reporting approximately 8,600 animals. The total market value of crops produced in both counties was more than $95 million; the total market value of livestock produced in both counties was more than $13 million.

Approximately 25% of the Teton Subbasin is federally or state-owned, and the majority of this land is managed by the Caribou-Targhee National Forest. Land use on the forest in the eastern portion of the subbasin, most of which is located in Wyoming, is determined primarily by its status as wilderness and grizzly bear habitat. The Jedediah Smith Wilderness Area, which borders Teton National Park, has experienced limited timber harvest but receives heavy recreational use with more than 60,000 visitors each year. Grand Targhee Ski and Summer Resort is adjacent to the wilderness area, and is a major destination of tourists. Management of forest lands in the Big Hole Mountains is directed toward opportunities for motorized and nonmotorized recreation, improvement of big game habitat, and improvement of ecosystem health. The Big Hole Mountains have been extensively logged and livestock grazing is a common land use.

Agriculture has historically been the principal land use influencing water quality in the Teton Subbasin. Of the thirteen segments on Idaho’s 1998 §303(d) list of water quality impaired waterbodies in the subbasin, sediment is cited as the pollutant responsible for impairment of nine. The principal processes that generate sediment are 1) sheet and rill erosion due to rain and snow runoff from cultivated fields and 2) streambank erosion due to grazing, channel alteration, and flood irrigation. Significant sources of sediment also include the collapse of Teton Dam; natural mass wasting events, particularly on Teton and Trail Creeks; and poorly maintained roads and culverts, particularly in areas where roads were constructed for timber harvest.

The other pollutants shown on Idaho’s 1998 §303(d) list are also associated primarily with agricultural land uses. Flow alteration occurs because flow is diverted from streams for use as irrigation water. Habitat alteration, particularly fish spawning habitat, is directly related to the accumulation of sediment in stream substrates. Thermal modification (i.e., temperature) has been attributed to removal of riparian vegetation and loss of shade, apparently due to grazing. Nutrients, particularly nitrogen, have been attributed to cattle manure, fertilizer, and crops such as alfalfa hay.

The effects of agricultural practices on water quality in the Teton Subbasin have not gone unnoticed by the agricultural community, and for more than fifty years, the Madison Soil and Water Conservation District and Teton Soil Conservation District have actively promoted resource conservation practices within the subbasin. Both districts have worked closely with the United States Department of Agriculture (USDA) Natural Resources Conservation Service to educate farmers about conservation practices and to obtain funding to assist farmers in implementing those practices. In fact, many of the streams that appear on Idaho's 1998 §303(d) list were originally listed because the Teton Soil Conservation District (TSCD) requested assistance from the Idaho Department of Health and Welfare in identifying water quality problems. Because of the activities of the conservation districts, the most erodible croplands have been removed from cultivation through the Conservation Reserve Program. Within the last fifteen years in the Teton Valley, the widespread practice of leaving fields fallow in summer has been completely replaced by practices that incorporate residue management and conservation tillage. These practices have significantly reduced the amount of soil transported to surface waters in the valley. Currently, the conservation districts are working through the USDA Environmental Quality Incentives Program to expand implementation of conservation practices.

Because of rapidly changing land uses, activities other than agriculture will have an increasingly important influence on water quality in the Teton Subbasin in the future. Since 1990, population growth in the Teton Subbasin has surged, particularly in the Teton Valley area. In 1990, the population of the Teton Subbasin was less than 30,000, with more than 87% of the population residing in Madison County. From 1990 to 1998, the population of Teton County, Idaho, increased by almost 60% and the population of Teton County, Wyoming, increased by almost 27%. By comparison, the population of the entire United States grew less than 9% during the same period. Population growth in the lower subbasin had been relatively stable until 2001 when Rick's College, a two-year college located at Rexburg, was converted to the Idaho campus of Brigham Young University. This prompted an immediate boom in construction of single-family and multiple-unit dwellings in anticipation of growing faculty, staff, and student populations.

Rural sprawl is the name given to the pattern of housing development currently occurring in the Teton Subbasin, particularly in the Teton Valley. Because of the aesthetic and recreational values offered by the area, and a lower cost of living relative to Jackson, Wyoming, land is becoming much more valuable for development than for farming. New residents do not settle in established communities, but on lots surrounded by several acres that simulate a rural lifestyle. During a six-year period from 1991 to 1997, approximately 4,000 acres of farmland in the Teton Valley were subdivided for construction of single-family homes, and approximately 150 subdivisions had been platted by 1997. Several additional subdivisions have been approved since 1997, and at least two planned communities are currently being developed. One community offers 85 single-family residences and at least 70 multiple housing units; the other features a golf course and 540 housing units. Factors related to rural development that may affect ground and water quality include, but are not limited to, the following: a reduction in total wetland acreage, subdivision of wetlands into smaller and less functional wetland parcels, alteration of subsurface water tables due to loss of wetlands, alterations of spring and surface water flows, increased numbers of septic systems, increased numbers of drinking water wells, and increased road construction and maintenance.

Only two point-source discharges that require permits under the National Pollutant Discharge Elimination System are located in the Teton Subbasin. The municipal wastewater treatment system at Driggs was recently upgraded to allow for regionalization of wastewater treatment, and a collection system extending from Driggs to the community of Victor at the southern end of Teton Valley was completed in 1999. Based on available information, the Driggs facility does not appear to contribute increased concentrations of nutrients to the Teton River, where it discharges after flowing through approximately five miles of wet meadow. The second municipal wastewater treatment system in the subbasin is at Rexburg, and discharges directly to the South Fork Teton River when weather conditions permit. The Rexburg facility influences water quality to the extent that at certain times of the year treated wastewater is a major source of water in the South Fork Teton River, its receiving water. However, the South Fork is downstream of any §303(d) listed segments in this subbasin.

Generally, the quality of water in the Teton Subbasin is good, as indicated by the continued presence of the native Yellowstone cutthroat trout (*Onchorhynchus clarki bouvieri*). This subspecies of cutthroat trout is an Idaho "species of special concern" because it is low in numbers, limited in distribution, and has suffered significant habitat losses. The U.S. Fish and Wildlife Service was petitioned to list the Yellowstone cutthroat trout as threatened under the Endangered Species Act, but in February 2001, the U.S. Fish and Wildlife Service concluded that the petition did not provide substantial biological information to indicate that listing was warranted. The decline of Yellowstone cutthroat trout throughout its range has been attributed primarily to hybridization with rainbow trout (*Onchorhynchus mykiss sp.*). In the Teton Subbasin, reproductive isolation between cutthroat and rainbow trout has apparently prevented hybridization in most areas, providing a genetic refuge. Although the abundance of cutthroat trout in the Teton Subbasin has been reduced due to habitat degradation, the subbasin is one of seven in the Greater Yellowstone Ecosystem that has been identified as offering a significant opportunity for restoration.

The objectives of the Teton Subbasin assessment are to identify waterbodies that 1) require development of a total maximum daily load (TMDL), 2) may be removed from the §303(d) list because they are not impaired, 3) must be deferred for TMDL development until a later date because of insufficient data on which to develop a load allocation, 4) are not subject to TMDL development because the pollutant responsible for impairment is habitat modification or flow alteration, or 5) are candidates for future §303(d) listing. The goal of a TMDL is to restore an impaired waterbody to a condition that meets state water quality standards and supports designated beneficial uses. A TMDL is the sum of the individual wasteload allocations for point sources of a pollutant, load allocations for nonpoint sources and natural background levels, and a margin of safety. Because of the variety of ways in which nonpoint source pollutants may enter a waterbody, a TMDL must also address seasonal variations in pollutant loading and critical conditions that contribute to pollutant loading.

The approach used to develop a TMDL incorporates several assumptions regarding our knowledge of natural systems and human-caused changes in natural systems. These assumptions include 1) that the amount of a pollutant that can be assimilated by a waterbody without violating water quality standards and impairing beneficial uses is known and can be quantified, 2) that natural background levels of a pollutant are known or can be determined, 3) that violations of water quality standards or impairments of beneficial uses can be directly linked to a single pollutant, and 4) that the data required to develop a load for a particular waterbody is available or can be readily obtained. None of these assumptions were valid for waterbodies in the Teton Subbasin. The Region 10 Office of the U.S. Environmental Protection Agency acknowledges the uncertainty associated with these assumptions, and has proposed an adaptive management strategy for addressing this uncertainty.

An adaptive management TMDL emphasizes near-term actions to improve water quality and can be employed when data only weakly quantify links between sources, allocations, and in-stream targets. Limited water quality data were available for the §303(d)-listed stream segments in the Teton Subbasin. Although load allocations have been developed for most of these segments, these allocations are based on information gathered more than ten years ago. Due to improved farming practices (e.g., elimination of summer fallow in the Teton Valley) and changes in land use, pollutant sources and resource concerns have changed since this information was collected. An adaptive management strategy makes provisions for addressing these changes during the implementation phase of the TMDL.

The adaptive management strategy will be incorporated into the TMDL Implementation Plan developed by designated management agencies. The designated roles of numerous government agencies in implementing Idaho's nonpoint source management program and TMDLs are described in the *Idaho Nonpoint Source Management Plan* (DEQ 1999b). An implementation plan for privately owned agricultural lands will be developed by the Soil Conservation Commission and Idaho Association of Soil Conservation Districts in cooperation with the Madison Soil and Water Conservation District, TSCD, and Yellowstone Soil Conservation District, with technical support from the affiliated field offices of the Natural Resources Conservation Service. Implementation plans for publicly owned lands in the Teton Subbasin will be the responsibility of the Idaho Department of Lands, U.S. Forest Service, Bureau of Land Management, and Bureau of Reclamation. Within 18 months of approval of the *Teton Subbasin Assessment and Total Maximum Daily Load (TMDL)* by the U.S. Environmental Protection Agency, the Idaho Falls Regional Office of DEQ will review each implementation plan and facilitate coordination among designated agencies to integrate the plans into a single, comprehensive implementation plan.

Conclusions based on the subbasin assessment are shown in the following table

Table A. Allocations of total maximum daily loads (TMDLs) and deferrals of TMDLs for §303(d) listed streams in the Teton Subbasin.

Waterbody	WQLS[1] Number	Boundaries	Pollutant(s)	Stream Miles	Load Allocations and Other Actions
Badger Creek	2125	Highway 32 to Teton River	Sediment	8.51	16,367 tons/year sediment (38% reduction).
Darby Creek	2134	Highway 33 to Teton River	Sediment Flow alteration	3.48	694 tons/year sediment (73% reduction). No TMDL for flow alteration.
Fox Creek	2136	Wyoming Line to Teton River	Sediment Temperature Flow alteration	9.18	949 tons/year sediment (72% reduction). Temperature TMDL rescheduled for end of 2002. No TMDL for flow alteration.
Horseshoe Creek	2130	Confluence of North and South Forks to Teton River	Flow alteration	7.03	No TMDL for flow alteration.
Moody Creek	2119	Forest boundary to Teton River	Nutrients	25.38	Nutrient TMDL rescheduled for the end of 2002.
North Leigh Creek	5230	Wyoming line to Spring Creek	Unknown[2]	4.90	Included in the Spring Creek watershed and TMDL.
Packsaddle Creek	2129	Headwaters to Teton River	Sediment Flow alteration	9.88	1,924 tons/year sediment (46% reduction). No TMDL for flow alteration.
South Leigh Creek	2128	Wyoming line to Teton River	Sediment	11.30	8,269 tons/year sediment (46% reduction).
Spring Creek	2127	Wyoming line to Teton River	Sediment Temperature Flow alteration	12.60	12,027 tons/year sediment (42% reduction). Temperature TMDL rescheduled for end of 2002. No TMDL for flow alteration.
Teton River	2118	Headwaters to Trail Creek	Habitat alteration	2.65	No TMDL for habitat alteration.
Teton River	2117	Trail Creek to Highway 33	Sediment Habitat alteration	20.00	105,141 tons/year sediment (41% reduction). No TMDL for habitat alteration.
Teton River	2116	Highway 33 to Bitch Creek	Sediment Habitat alteration Nutrients	10.10	121,508 tons/year sediment (41% reduction). 101,882 lbs/year total phosphorus (78% reduction). No TMDL for habitat alteration.
North Fork Teton River	2113	Forks to Henry's Fork, Snake River	Sediment Nutrients	14.64	52,818 tons/year sediment (41% reduction). 66,149 lbs/year total phosphorus (67% reduction). 198,448 lbs/year nitrate (8% total reduction).

[1]WQLS: Water quality limited segment shown in the 1998 §303(d) list.
[2]North Leigh Creek was added to the 1998 §303(d) list because beneficial use reconnaissance program data collected by DEQ indicated that beneficial uses were not supported. The pollutant responsible for impairment of beneficial uses cannot be determined using BURP data alone, so a pollutant was not listed. Because a U.S. Department of Agriculture 1992 sediment yield study included North Leigh Creek in the Spring Creek watershed and in Spring Creek's yield calculation, we consider it part of the Spring Creek TMDL.

TETON SUBBASIN ASSESSMENT

INTRODUCTION

This subbasin assessment was prepared pursuant to the Idaho total maximum daily load (TMDL) development schedule (Idaho Sportsmen's Coalition v. Browner, No. C93-943WD, Stipulation and Proposed Order on Schedule Required by Court, April 7, 1997), §303(d) of the Clean Water Act (Public Law 92-500 as amended, 33 U.S.C. §1251 *et seq.*), and the United States Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130.7).

The objective of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical and biological integrity of the Nation's waters" (33 U.S.C. §1251 *et seq.*). To achieve this objective, the CWA specifies several national goals and policies, including the following:

1) It is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985
2) It is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983

   ...and

7) It is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.

Despite implementation of numerous provisions of the CWA, many of the nation's waters still have not been restored to a "fishable and swimmable" condition. Section 303(d) of the CWA (refer to Appendix A for entire text) addresses these remaining waters by requiring that states submit biennially a list of water quality impaired waterbodies (i.e., a §303(d) list) to the EPA. With oversight from the EPA, the states are then responsible for developing a TMDL for the pollutant or pollutants responsible for impairment of each waterbody (EPA 1996).

The goal of the TMDL is to restore the impaired waterbody to a condition that meets state water quality standards. According to the EPA (1996),

> A TMDL is a written, quantitative assessment of water quality problems and contributing pollutant sources. It specifies the amount of a pollutant or other stressor that needs to be reduced to meet water quality standards, allocates pollution control responsibilities among pollution sources in a watershed, and provides a basis for taking actions needed to restore a waterbody. More specifically, a TMDL is the sum of the individual wasteload allocations (WLAs) for point sources [of pollution], load allocations (LAs) for nonpoint sources [of pollution] and natural background, and a margin of safety (MOS).

In 1997, the Idaho Department of Health and Welfare, Division of Environmental Quality (now Department of Environmental Quality [DEQ]), and Region 10 EPA finalized an eight-year schedule for developing TMDLs in Idaho. Background information regarding development of this schedule is contained in Appendix B. The EPA Region 10 approved the portion of the 1998 §303(d) list that pertains to the Teton Subbasin on May 1, 2000.

The subbasin assessment and TMDL is a three-step process that includes 1) preparing a subbasin assessment, 2) developing a TMDL or watershed management plan, and 3) developing an implementation plan.

The purpose of the subbasin assessment is to:

1) describe the physical, biological, and cultural attributes of the subbasin, particularly in relation to surface water resources;
2) summarize existing water quality information available for the drainage;
3) describe applicable water quality standards;
4) identify and evaluate pollution sources and disturbance activities that contribute to impairment of water quality;
5) summarize past and present pollution control efforts; and
6) outline water quality management needs including identifying those waterbodies that a) require development of a TMDL, b) may be removed from the §303(d) list because they are not impaired, c) are not subject to TMDL development because the pollutant responsible for impairment is habitat modification or flow alteration, or d) are candidates for §303(d) listing.

If the subbasin assessment demonstrates a 303(d) listed waterbody is not impaired and is meeting its designated beneficial uses and the water quality standards, DEQ will not develop a TMDL and will recommend de-listing of the waterbody in the next 303(d) listing cycle. If the EPA approves the revised list, a TMDL will not be developed for the excluded waterbody.

Conversely, if the subbasin assessment demonstrates that a waterbody not on the current §303(d) list is water quality impaired, the waterbody will be included on the next §303(d) list prepared for submission to EPA. TMDLs or management and control plans will not be developed for newly listed waterbodies until at least 2006, following completion of the current TMDL schedule. During this time, it is possible that the waterbody will be restored to a condition that meets water quality standards, making development of a TMDL unnecessary.

PHYSICAL CHARACTERISTICS OF THE TETON SUBBASIN

Topography

One of the most distinctive topographic features of the Teton Subbasin is the western slope of the Teton Mountain Range. The eastern slope of the Teton Range is among the most recognizable views in the world because its face rises abruptly from the Snake River valley below it. The unique peaks of the three Tetons remain recognizable from the west, although the peaks grade more gently into rolling farmland. Although total elevational changes within the subbasin are almost 6,000 feet from the eastern boundary of the subbasin in the Teton Mountains of Wyoming to the western boundary near the Henry's Fork River, this change occurs over a horizontal distance of up to 50 miles (Figure 1). Other unique features of the Teton Subbasin are the deep, steep-walled canyons of the Teton River, Badger Creek, Bitch Creek, Milk Creek, Canyon Creek, and Moody Creek. These canyons appear abruptly in a landscape of level or gently rolling farmland, and access to the canyons in most places is extremely difficult.

Three mountain ranges define the eastern, southeastern, and south central boundaries of the subbasin: the Teton, Snake River, and Big Hole mountain ranges. The Teton Valley, a north-south trending valley approximately five miles wide and 20 miles long, is defined by the convergence of these three mountain ranges. Elevations exceeding 10,000 feet occur along the entire length of the eastern boundary of the subbasin in the Teton Range. Streams originating from the Teton Range may drop as much as 4,000 feet in elevation as they flow a horizontal distance of less than 15 miles toward the Teton Valley.

Darby Creek originates near Fossil Mountain at an elevation of 10,912 feet (3,327 meters [m]), and Teton Creek originates near Battleship Mountain at an elevation of 10,676 feet (3,255 m). North of the valley in the northeast corner of the subbasin, Bitch Creek originates near Rammel Mountain at an elevation of 10,138 feet (3,091 m). Streams flowing toward the Teton Valley from the Snake River Range and Big Hole Mountains originate at elevations ranging from approximately 7,000 to 9,000 feet (2,130 -2,700 m). Trail Creek originates near Oliver Peak at an elevation of 9,003 feet (2,744 m), and Canyon Creek originates near Garns Mountain at an elevation of 9,013 feet (2,748 m). Streams originating in the Big Hole Mountains flow east into the Teton Valley, north into the Teton River Canyon, and west into the South Fork Teton River.

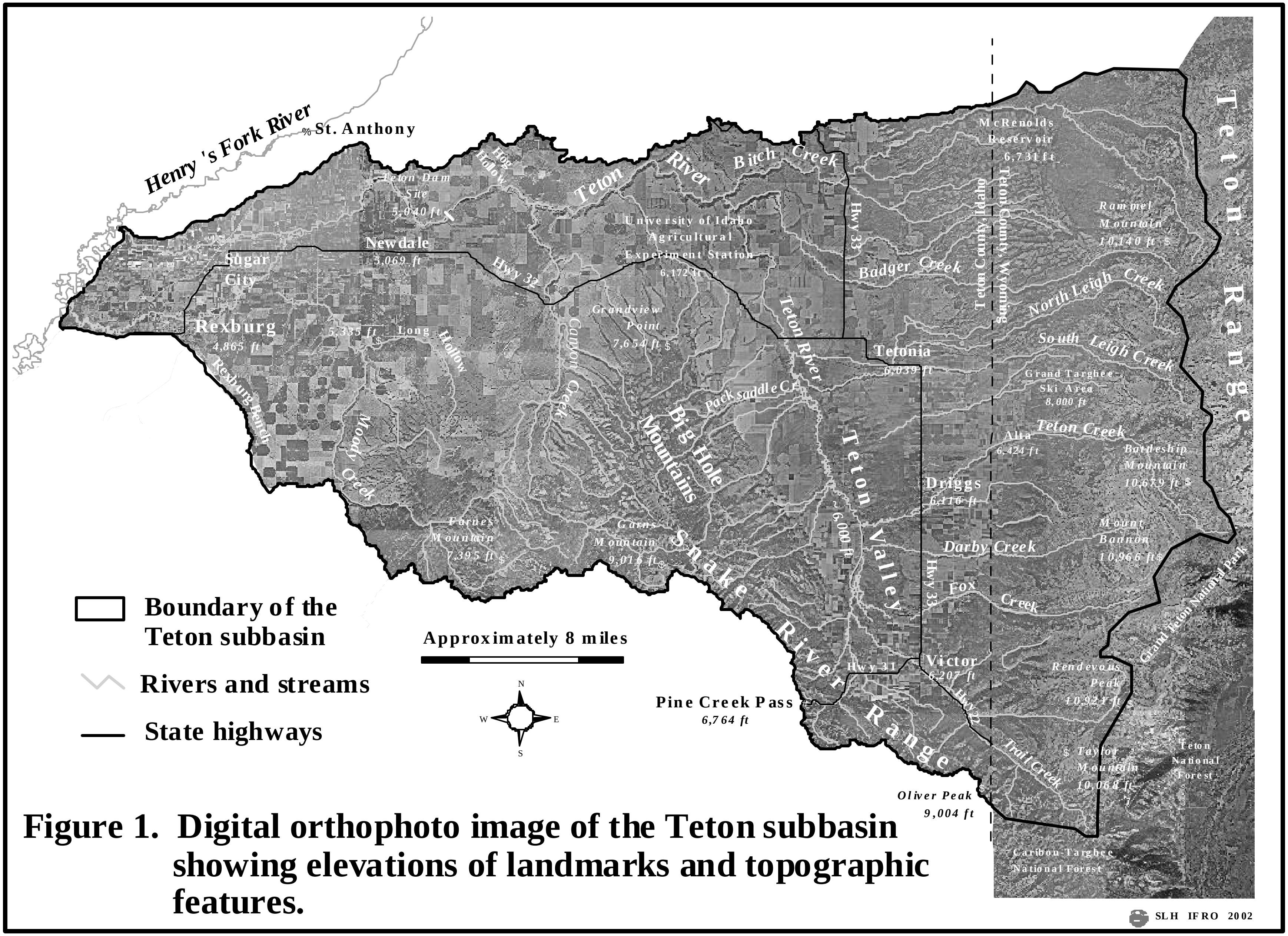


Figure 1. Digital orthophoto image of the Teton subbasin showing elevations of landmarks and topographic features.

Climate

Long-term, continuous climate data have been collected by the National Weather Service (NWS) at several locations in the Teton Subbasin. In the western portion of the subbasin, temperature and precipitation data were collected at Sugar City from 1948 until 1977, when the station was moved to Rick's College in Rexburg. In the eastern portion of the subbasin, an NWS climate station originally located at Felt in 1919 was moved to Tetonia in 1932 and then to the Tetonia Experiment Station in 1952 (USDA 1969). These three locations are within a six-mile radius of each other, and vary less than 100 feet in elevation. The only climate station in the subbasin that has remained in its original location is at Driggs. This station has been operational since 1907 (USDA 1969). The official names and numbers of the NWS Cooperative Stations currently operating in the Teton Subbasin are Rexburg Rick's College, number 107644; Tetonia Experiment Station, number 109065; and Driggs, number 102676 (Abramovich *et al.* 1998).

Temperatures within the Teton Subbasin generally decrease from west to east as elevations increase. These temperature changes correspond to elevational differences of 1,250 feet between Rexburg and the Tetonia Experiment Station, and 1,200 feet between Rexburg and Driggs (Table 1).

Higher temperatures in the western portion of the subbasin contribute to a longer growing season. The probable length of the growing season nine in every ten years is 82 days at Rexburg, 44 days at Driggs, and 34 days at the Tetonia Experiment Station (Table 2).

A comparison of the growing season at the Tetonia Experiment Station, which is 25 miles east of Rexburg, and the growing season at Driggs, which is 33 miles east of Rexburg, indicates that within the eastern portion of the subbasin, a relatively minor change in average temperature results in a noticeable change in growing season (Tables 2 and 3).

In the Teton Subbasin, average total precipitation is greatest in May and June, and average total snowfall is greatest in December and January (Table 4). Based on data from the three NWS climate stations in the subbasin, average total precipitation is approximately 12% less at Rexburg than at the Tetonia Experiment Station or Driggs. Average monthly precipitation at Rexburg exceeds the average at the Tetonia Experiment Station and Driggs only in May and November. But despite lower total precipitation, Rexburg receives approximately 17 inches more snow than the Tetonia Experiment Station and only eight inches less snow than Driggs (Table 4). Furthermore, the difference in total snowfall between the Tetonia Experiment Station and Driggs, a distance of less than ten miles, is almost 26 inches (Table 4). This pattern of snowfall over a relatively small distance seems to demonstrate the enormous influence of the Big Hole Mountains and the Teton Range on local climatic conditions.

Table 1. Average daily maximum and minimum temperatures measured at Sugar City and Rexburg[1], Tetonia Experiment Station[2], and Driggs[3].

Period	Average Daily Maximum Temperature (°F)			Average Daily Minimum Temperature (°F)		
	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs
January	28.9	28.1	29.6	9.0	5.4	5.9
February	34.7	33.2	34.5	13.5	8.9	9.5
March	44.4	39.3	40.5	20.9	15.0	16.3
April	56.7	49.8	51.9	29.1	25.1	25.6
May	67.3	61.7	62.8	37.5	32.9	33.5
June	75.2	70.7	71.1	43.7	39.4	40.1
July	84.1	80.5	81.1	47.9	44.8	46.1
August	83.7	79.1	80.0	45.8	42.9	43.9
September	73.9	69.4	70.5	37.6	35.3	36.3
October	60.6	56.7	58.6	29.1	26.9	27.7
November	42.7	39.8	41.0	21.0	16.3	17.1
December	31.0	30.1	32.2	11.1	7.6	8.9
Annual	56.9	53.2	54.5	28.9	25.0	25.9

[1]The values reported are time-weighted averages of data collected at Sugar City from 8/1/1948 to 5/1/1976 and at Rexburg from 7/1/1977 to 12/31/1998. Source: Western Regional Climate Center, *http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idsuga* and *http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idrexb*.
[2]Source: Western Regional Climate Center, *http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idteto*. Period of record: 5/18/1952 to 12/31/1998.
[3]Source: Western Regional Climate Center, *http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?iddrig*. Period of record: 1/3/1930 to 12/21/1998.

Table 2. Length of growing season: probabilities of the number of days at Rexburg, Driggs, and Tetonia that will exceed minimum temperatures of 24 °F, 28 °F, and 32 °F.[1]

Probability[2]	Number of days greater than 24 °F			Number of days greater than 28 °F			Number of days greater than 32 °F		
	Rexburg	Driggs	Tetonia	Rexburg	Driggs	Tetonia	Rexburg	Driggs	Tetonia
9 years in 10	146	113	95	118	80	68	82	44	34
5 years in 10	165	136	122	136	107	91	104	73	63
1 year in 10	183	158	148	154	133	113	126	102	93

[1]Source: Abramovich *et al*. (1998)
[2]Based on data collected from 1961 to 1990

Table 3. Length of growing season: probabilities that the last freezing temperature in spring and first freezing temperature in fall will occur later or earlier than a particular date in Rexburg, Driggs, and Tetonia.[1]

Probability that the last date will be later than the date shown and that the first date will be earlier than the date shown[2]	Last date in spring and first date in fall that the daily minimum temperature is:								
	equal to or less than 24 °F			equal to or less than 28 °F			equal to or less than 32 °F		
	Rexburg	Driggs	Tetonia	Rexburg	Driggs	Tetonia	Rexburg	Driggs	Tetonia
5 years in 10	April 21 Oct 4	May 10 Sept 24	May 16 Sept 20	May 11 Sept 25	May 27 Sept 13	June 3 Sept 8	May 30 Sept 12	June 19 Sept 2	June 23 Aug 28
2 years in 10	May 2 Sept 24	May 19 Sept 15	May 28 Sept 10	May 22 Sept 16	June 9 Sept 3	June 15 Aug 28	June 11 Sept 3	July 3 Aug 22	July 5 Aug 16
1 year in 10	May 8 Sept 19	May 25 Sept 9	June 4 Sept 5	May 29 Sept 11	June 15 Aug 29	June 22 Aug 23	June 17 Aug 28	July 11 Aug 15	July 11 Aug 10

[1]Source: Abramovich *et al*. (1998)
[2]Based on data collected from 1961 to 1990

Table 4. Summary of precipitation and snowfall data collected within the Teton Subbasin at Sugar City and Rexburg[1], Tetonia Experiment Station[2], and Driggs[3].

Period	Average Total Precipitation (Inches)			Average Total Snowfall (Inches)			Average Snow Depth (Inches)		
	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs
January	1.1	1.5	1.4	13.1	16.1	14.9	9	2	13
February	1.0	1.0	1.1	10.3	2.9	8.6	7	1	13
March	1.1	1.0	1.2	4.8	2.1	9.1	3	0	6
April	1.2	1.3	1.2	2.5	1.4	4.8	0	0	1
May	2.1	2.1	1.8	0.5	0.5	1.6	0	0	0
June	1.5	1.8	1.9	0.0	0.0	0.2	0	0	0
July	1.0	1.1	1.1	0.0	0.0	0.0	0	0	0
August	0.7	1.1	1.2	0.0	0.0	0.0	0	0	0
September	0.9	1.3	1.2	0.1	0.3	0.4	0	0	0
October	1.0	1.2	1.2	1.3	0.7	2.0	0	0	0
November	1.3	1.0	1.1	7.0	5.5	8.6	1	1	1
December	1.1	1.4	1.4	16.2	9.2	14.2	5	6	6
Annual	14.0	15.9	15.7	55.7	38.7	64.5	2	3	3

[1]The values reported are time-weighted averages of data collected at Sugar City from 8/1/1948 to 5/1/1976 and at Rexburg from 7/1/1977 to 12/31/1998. Source: Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idsuga and http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idrexb.
[2]Source: Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idteto. Period of record: 5/18/1952 to 12/31/1998.
[3]Source: Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?iddrig. Period of record: 1/3/1930 to 12/21/1998.

Snow pack at higher elevations within the subbasin are monitored at the Pine Creek Pass snow telemetry (SNOTEL) station and three snow course stations operated by the Natural Resources Conservation Service (NRCS). The Pine Creek SNOTEL station is located along the southeastern divide between the Teton and Palisades Subbasins at an elevation of 6,720 feet. The data collected at this station since October 1988 can be accessed through the Western Regional Climate Center Internet site at http://www.wrcc.dri.edu/cgi-bin, and a summary of average monthly snow water equivalent data is shown in Table 5. Snow water equivalent values are highest on April 1, and rapidly decline between May 1 and June 1 (Table 5).

Peak flows in streams and rivers throughout the subbasin are generally caused by a combination of spring rains and snowmelt. Average total precipitation reaches a maximum throughout the subbasin in May and June, which coincides with warmer average daily temperatures (Table 1) and rapidly decreasing snow depth (Table 4). According to England (1998), snowmelt is the predominant cause of runoff in the Teton Subbasin, and snowmelt high runoff, as measured in the Teton River near St. Anthony gage station, occurs in June.

Table 5. Average values for snow depths and snow water equivalents (SWE) measured at Natural Resources Conservation Service SNOTEL and snow course stations in the Teton Subbasin from 1961 to 1990[1].

	Station Name and Type							
	McRenolds Reservoir Snow Course		Packsaddle Spring Snow Course		Pine Creek Pass SNOTEL		State Line Snow Course	
Date	Depth (inches)	SWE (inches)	Depth (inches)	SWE (inches)	Depth (inches)	SWE (inches)	Depth (inches)	SWE (inches)
January 1	-[2]	7.6	-	12.2	31	6.9	28	6.1
February 1	-	12.5	-	18.2	43	11.3	38	9.8
March 1	-	16.6	-	24.3	49	15.1	43	12.7
April 1	-	19.2	-	27.5	49	17.2	45	14.8
May 1	-	14.2	-	25.1	27	11.3	20	8.2
June 1	--[3]	--	--	--	-	0.7	-	0.5

[1]Source: Abramovich *et al.* (1998)
[2]Not reported
[3]No measurable snow

Geology

At least two, and possibly three, physiographic provinces converge in the Teton Subbasin. According to Short (1999), the western and central portions of the subbasin are within the Snake River Plain physiographic subprovince of the Colorado Plateau, and the eastern portion of the subbasin is within the Middle Rocky Mountains province. Stevenson (1990a, 1990b) adds a third province by placing the Big Hole Mountains of the south central portion of the subbasin within the Basin and Range physiographic province. The distinctions between these provinces are apparent in the varied geomorphology, topography, and soils of the subbasin.

The *Geologic Map of Idaho* (IDL 1978) shows nineteen distinct geologic units within the Teton Subbasin. For simplicity, these units have been combined into the four categories shown in Figure 2. The sedimentary deposits of the Big Hole, Snake River, and Teton Mountain Ranges formed 65 to 245 million years ago when ancient oceans and lakes existed in this region. The limestones, sandstones, siltstones, and shales that comprise these deposits were folded and faulted, displacing the Teton Mountain Range upward 20,000 feet and forming the Big Hole Mountains and Snake River Range. A structural basin, underlain by Mesozoic-age bedrock, was also formed by this process, and is referred to as the Teton Basin or Teton Valley.

The Teton Valley is bounded by the Big Hole Mountains on the west, the Snake River Range on the south, and the Teton Range on the east. The valley is approximately five miles wide and 20 miles long. The north end of the valley was originally blocked by volcanic deposits, which created a lake-type depositional area (Stevenson 1990a). During the Quarternary Period, 1.6 to 0.01 million years ago, the area filled with detritus formed from the weathering of the surrounding mountains. According to Wood (1996),

> as the surrounding mountains were uplifted, alluvial-fan deposits began to accumulate rapidly on their flanks. The higher elevations were subject to erosion...while the lower elevations were subject to deposition of alluvial sediments, silts, sands and gravels. ... In the alluvial fans the coarsest debris [pebbles and boulders] is nearest the mouths of the tributary canyons. The size then decreases toward the base of the fans where the debris consists largely of clay, silt, sand, and small gravel. Such deposits are the result of erratic conditions of streamflow where the fan may at one time have received coarse material carried by a flood and soon after received only the finer sediments carried by the stream. ... From time to time, volcanic rocks of silicic composition, probably closely allied with those in the Yellowstone Park area, flowed out across the valley, covering or interlayering with the alluvial sand and gravels.

During the Pleistocene Epoch of the Quarternary Period, the Teton Mountains, and possibly the Big Hole Mountains, were glaciated in three recognized stages. “Glacial drift, consisting of poorly sorted sand, gravel, and boulders, was deposited in nearly all the tributary canyons in the Teton Range” (Wood 1996). These deposits were overlain by wind-blown silt, covering much of the valley floor west of the Teton River and in the northern and northeastern parts of the valley; the depth of loess in these areas ranges from 0 to 100 feet (Wood 1996).

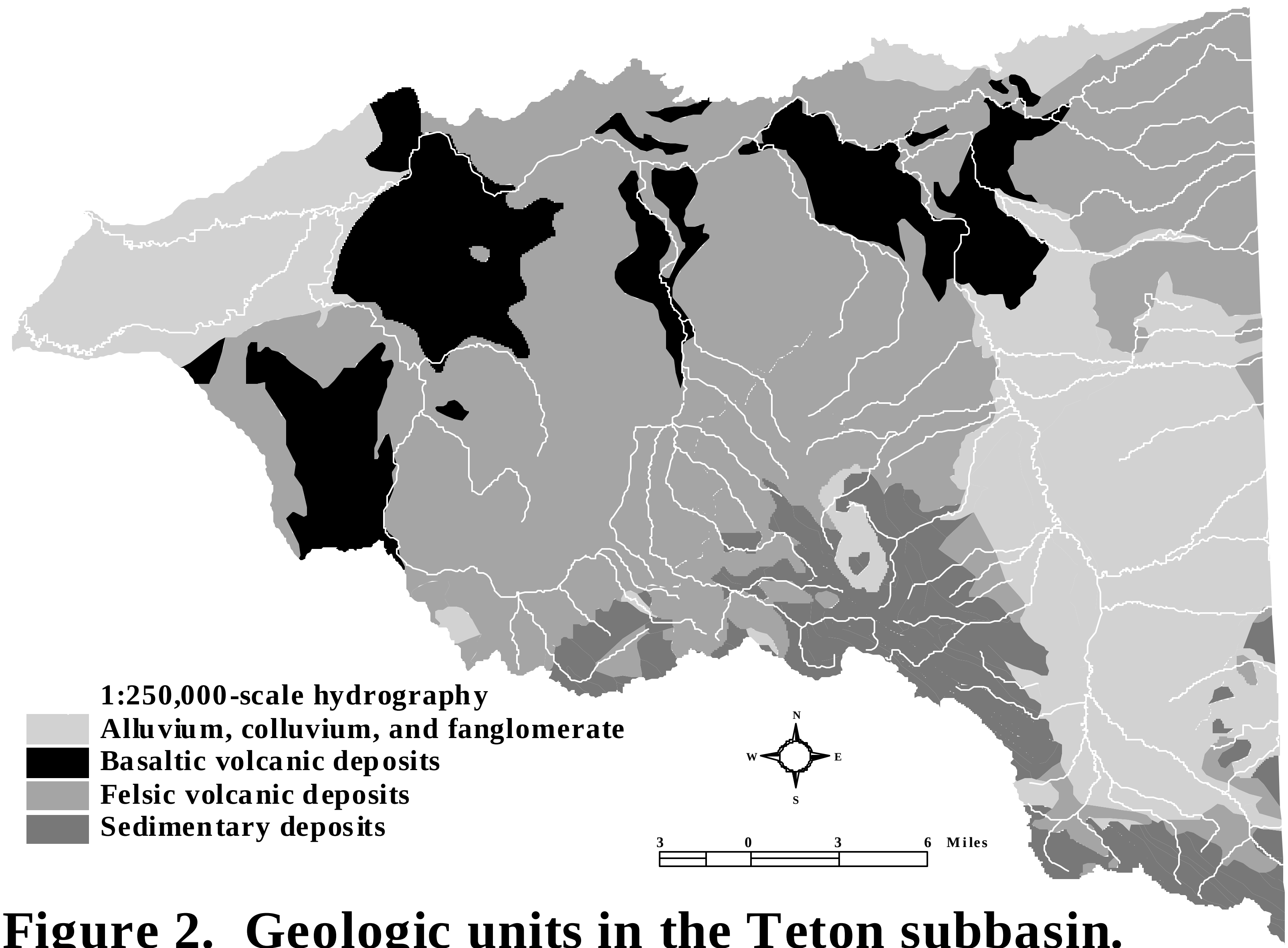


Figure 2. Geologic units in the Teton subbasin.

The felsic volcanic deposits found at the northern end of the Teton Basin are similar to those of the central portion of the subbasin. Rhyolite rock is found at the surface at numerous locations, and extends to a depth of 860 feet in the Bitch Creek subwatershed (Wood 1996). The basalts that occur at the very northern extent of the valley were deposited between periods of felsic deposition. Eventually, the Teton River eroded a steep-walled canyon through the basalt at the northern end of the valley. As the river flows through volcanic deposits, its course appears to be determined by the locations of large deposits of basalt. At the confluence of Bitch Creek, the river makes an almost 90^o turn to the west as it flows along the northern extent of a large basalt formation (Figure 2).

The channels of several large tributary streams of the Teton River were also apparently determined by the locations of basalt formations (Figure 2). Badger Creek, Bitch Creek, Milk Creek, Canyon Creek, and Moody Creek have each carved steep-walled canyons that appear abruptly in a landscape otherwise characterized by rolling loess-covered hills. Randle *et al.* (2000) describes the geologic formation of the Teton River canyon as follows.

> During the late Pliocene and early Pleistocene age (2.1 million years ago), the Huckleberry Ridge tuff, a 200- to 600- foot-thick flow of rhyolite from Yellowstone Caldera, was deposited over a pre-existing uneven landscape (Pierce and Morgan, 1992). The Teton River started downcutting through the rhyolite, likely due to uplifting of the Rexburg Bench in relation to the subsidence of the adjacent Snake River Plain to the west. Following incision of the Teton River into the Huckleberry Ridge tuff, a single younger basalt flow entered the Teton River canyon just downstream from the present dam site and flowed upstream, covering river gravel and filling the lower part of the canyon to a depth of about 125 feet (Magleby, 1968). The Teton River continued its active erosion cycle and extensively eroded the intracanyon basalt flow. The lower river near the dam site then changed from degradation to aggradation, resulting in the deposition of over 100 feet of sand and gravel, completely burying the remnants of the intracanyon basalt flow (Magleby, 1968). ...Today, steep canyon walls typically rise 300 to 500 feet above the river in the nearly 17-mile-long reach upstream from Teton Dam that was inundated by Teton Reservoir.

After the Teton River exits the canyon, it flows through a geologic area described as “Pleistocene outwash fanglomerate flood and terrace gravels” (IDL 1978). In this area, materials washed out of Pleistocene glaciers and deposited in the alluvial fan of the river have cemented into solid rock (i.e., fanglomerate). This geologic formation, like the formations described for the Teton Valley, overlays and is probably interlayed with materials of volcanic origin. In fact, all of the western Teton Subbasin lies within the Kilgore caldera, formed by the same events that created the eastern Snake River Plain.

Formation of the eastern Snake River Plain began 10 to 17 million years ago when a volcanic system located in what is now southwestern Idaho began migrating in a northeasterly direction at an estimated rate of 4.5 millimeters (mm) per year (Link and Phoenix 1996) to 2 to 4 centimeters (cm) per year (Christiansen and Embree 1987, Maley 1987). This system is produced by movement of the North American tectonic plate southwestward over a stationary plume of heat in the earth's mantle (the Snake River Plain-Yellowstone Hot Spot) (Link and Phoenix 1996). As the continental crust passes above the hot spot, it melts,

> ...producing explosive eruptions of light-colored lava or ash, with the composition of rhyolite. These eruptions coincide with collapse of calderas (topographic depressions formed after the rhyolitic volcanic eruptions) which form above what had been magma chambers. ... After the rhyolite eruptions have ceased, dark lava known as basalt is erupted, and covers over the subsided rhyolite topography. ...after rhyolite eruptions cease, thermal doming of the land surface is reduced and the area subsides back to near its prior elevation (Link and Phoenix 1996).

This process is considered responsible for a series of caldera-forming eruptions that have propagated in a northeasterly direction to form the eastern Snake River Plain. The leading edge of the volcanic system, the Yellowstone resurgent caldera (Alt and Hyndman 1989) or Yellowstone Plateau volcanic field (Christiansen and Embree 1987), is located at the eastern edge of the Upper Henry's Fork Subbasin. Resurgent calderas erupt enormous volumes of rhyolite lava at intervals of several hundreds of thousands of years. The Yellowstone resurgent caldera has erupted three times at intervals of approximately 600,000 years, creating the Henry's Fork, Huckleberry Ridge, and Yellowstone calderas. Three million years earlier, the resurgent caldera erupted in what is now the western half of the Teton Subbasin, creating the Kilgore caldera.

The Kilgore caldera extends south of present-day Rexburg to Heise and north to the Centennial Mountains (Hackett *et al.* 1986). The surface features of the Kilgore caldera are no longer discernable. Because the Kilgore caldera covers an area approximately the size of the Henry's Fork, Huckleberry Ridge, and Yellowstone calderas combined, the volume of eruptive material produced by Kilgore must have exceeded 3,500 cubic kilometers (km^3). By comparison, eruption of Mount St. Helens produced less than 2 km^3 of material (Wood 1996).

Hydrography and Hydrology

The Henry's Fork basin is comprised of the Upper Henry's Fork Subbasin, the Lower Henry's Fork Subbasin, and the Teton Subbasin. Immediately south of the Teton Subbasin, the Henry's Fork River joins the South Fork Snake River to form the mainstem of the Snake River (Figure 3).

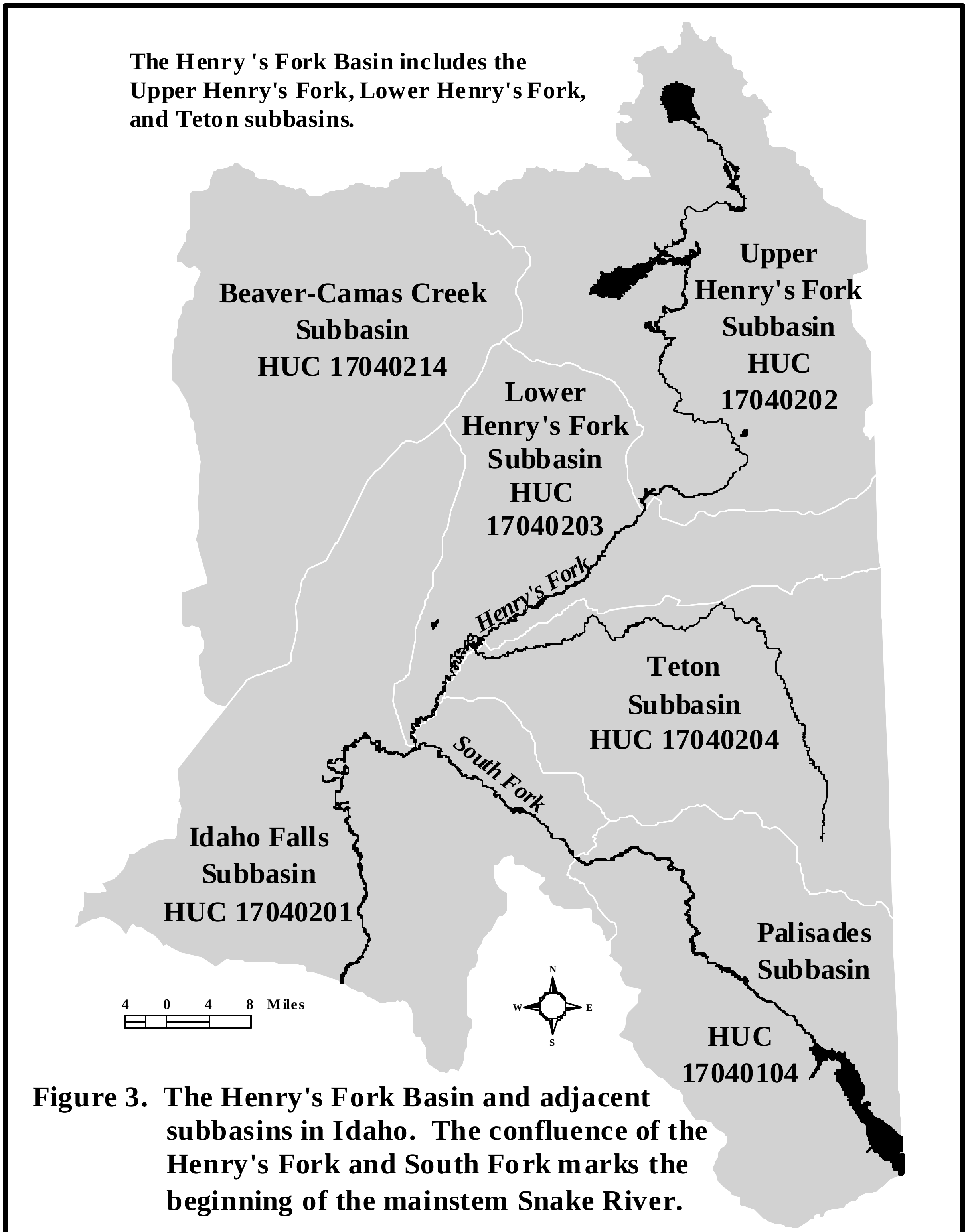


Figure 3. The Henry's Fork Basin and adjacent subbasins in Idaho. The confluence of the Henry's Fork and South Fork marks the beginning of the mainstem Snake River.

The Teton River drains an area of 806 square miles in Idaho and 327 square miles in Wyoming. The river originates from headwater streams in the Teton, Snake River and Big Hole Mountain Ranges and flows more than 64 miles to the point at which it discharges to the Henry's Fork of the Snake River. Approximately 16 river miles upstream from its discharge point, the Teton River divides into two channels. On U.S. Geological Survey (USGS) topographic maps, the northernmost channel is named *Teton River* and the southernmost channel is named *South Teton River*. But these channels are more commonly known as the North Fork and South Fork Teton River, and are referred to as such throughout this document.

The USGS has operated gage stations at 24 locations within the Teton Subbasin, though only four stations are currently in operation (Figure 4 and Appendix C). Several of the discontinued stations were located on tributary streams in the upper subbasin, and most of these were operational only from 1946 through the early 1950s. One station, *Teton River near St. Anthony*, has been operating discontinuously since 1890. Water quality data have also been collected at this station for the following intervals: water years 1977-1981, October 1989 to September 1990, November 1992 to September 1996, and water year 1999.

Discharge data for the four active gage stations in the Teton Subbasin are presented in graphical form in Figure 5. These graphs were taken directly from the USGS web site for water years 1981-1999, the period during which all stations were operating.

England (1998) analyzed flood frequency and flow duration for the Teton River as part of the Bureau of Reclamation's (BOR's) Teton Canyon restoration study. His conclusions include 1) flooding in the Teton Subbasin is caused by three mechanisms: warm rains from winter storm systems, spring rain-on-snow, and snowmelt; 2) the largest peak discharges are caused by winter storms, although flow volumes for rainfall-dominated floods are substantially less than snowmelt-dominated floods; 3) snowmelt is the predominant cause of runoff in the Teton Subbasin; and 4) the snowmelt high runoff at the *Teton River near St. Anthony* gage occurs in June. But the maximum discharge recorded at the *Teton River near St. Anthony* gage, excluding the peak estimated on June 5, 1976 following the Teton Dam collapse, occurred in February 1962 (Appendix C). The peak flow of 11,000 cubic feet per second (cfs) was caused by a combination of factors that included prolonged rainfall and unusually warm temperatures, and produced damaging floods in Rexburg, Sugar City, and Teton. Philbin (2001) reviewed the unit discharge data shown in Appendix C and concluded that peak flows in the upper subbasin are driven by snowmelt whereas peak flows in the lower subbasin are driven by spring rains on saturated soils.

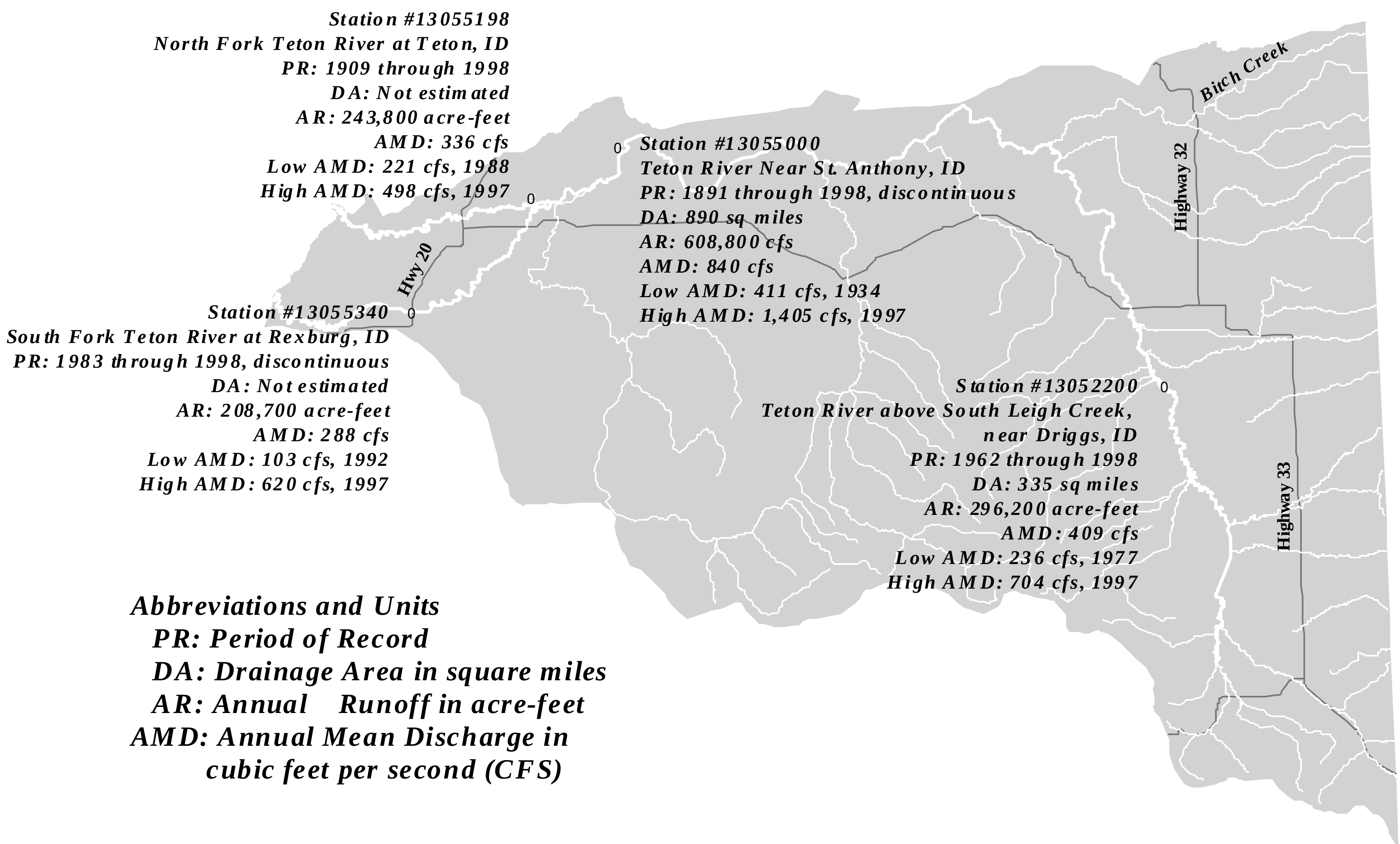


Figure 4. Locations of U.S. Geological Survey surface-water stations currently operating in the Teton subbasin, and summaries of discharge data for the period of record through 1998. Source: U.S. Geological Survey Water-Data Report ID-98-1.

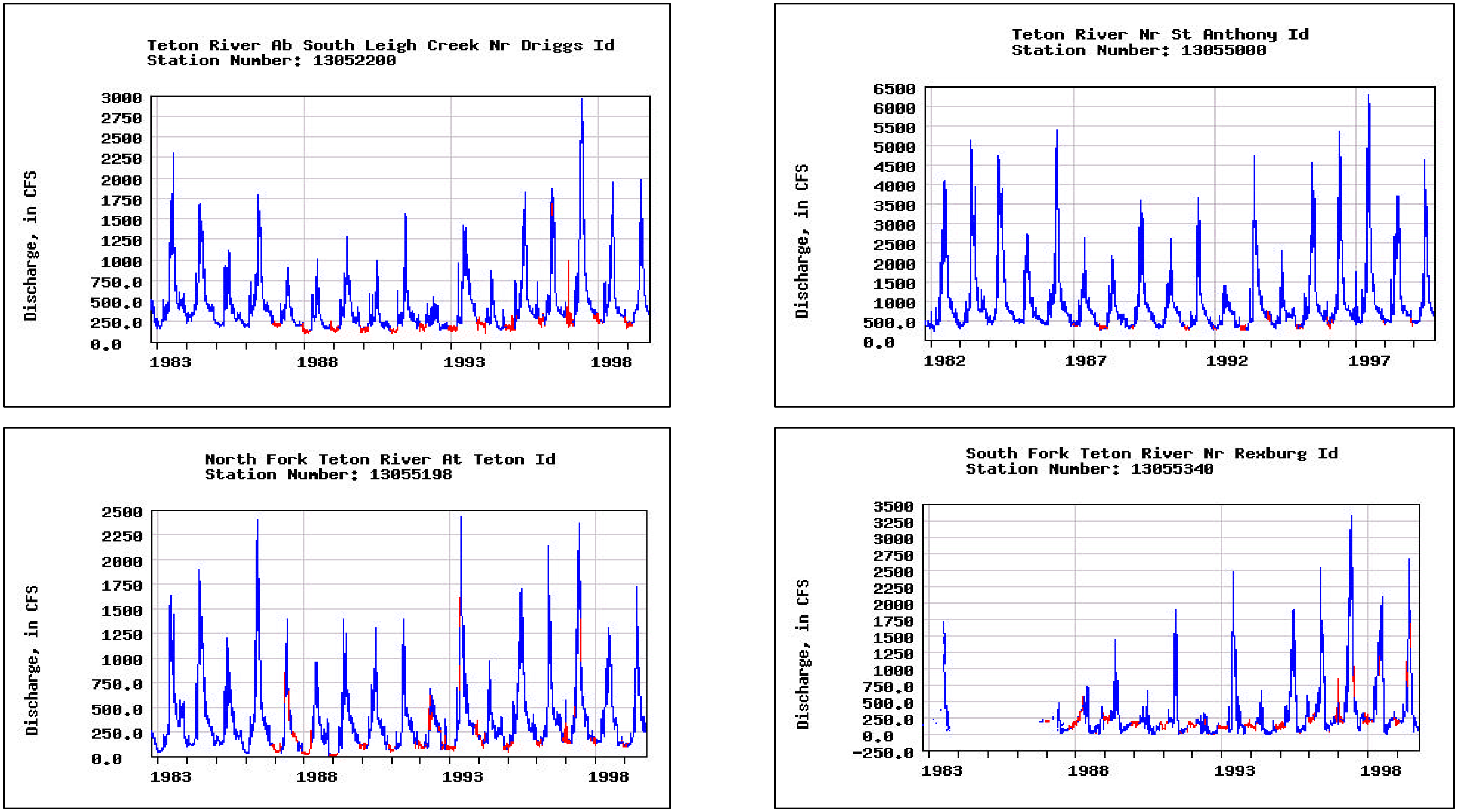


Figure 5. Discharge data recorded or estimated since 1982 at active USGS gage stations in the Teton subbasin. Graphs were taken directly from the USGS data retrieval site at http://waterdata.usgs.gov/nwis-w/ID.

Comparisons of the maximum unit discharges shown in Appendix C are indicative of the relative importance of the Bitch Creek subwatershed to the entire Teton Subbasin. The maximum unit discharge recorded for Bitch Creek (23.2 cfs/mile^2) was almost twice the maximum unit discharge recorded for the entire subbasin upstream of the *Teton River near St. Anthony* gage (12.4 cfs/mile^2). It was more than four times the maximum unit discharge recorded for the entire subbasin upstream of Bitch Creek, as measured at the *Teton River below Badger Creek* gage (4.9 cfs/mile^2). The contribution of Bitch Creek to surface flow is so significant that when the first survey map of the upper Teton Subbasin was produced, the Teton River was named *Pierre's River*, and Bitch Creek was labeled *North Fork of Pierre's River* (Thompson and Thompson 1981). Bitch Creek is still often referred to as the North Fork by residents of the Teton Valley.

The waters of the Teton Subbasin have been used intensively for irrigation since the late 1800s, and natural flow regimes have been significantly altered throughout the subbasin (Carter and Steele 1955, USDA 1981). Water users in the Teton Subbasin are served by the Fremont-Madison Irrigation District (FMID), which is defined geographically by the Henry's Fork Basin (FMID 1992). The district was organized in 1935, and has acted as a forum for, and representative of, water-related issues in Fremont, Madison, and Teton counties. The BOR provides a total of 150,204 acre-feet of storage space in Island Park and Grassy Lake Reservoirs to FMID. The FMID does not own any water supply and distribution facilities outright, but it manages and maintains the Crosscut Canal and the BOR's five exchange wells. The Crosscut Canal provides water from Island Park Reservoir to water users who divert from the Teton River by transferring storage water from the Henry's Fork River near Chester to the Teton River upstream of the forks. The exchange wells were constructed by the BOR in the 1970s as appurtenances of the Teton Basin Project to provide additional irrigation water in dry years. Although the Teton Basin Project was not completed because of the failure of the Teton Dam, water in the exchange wells replaces waters diverted to district entities during low water years. A list of diversions from, and returns to, the lower Teton River, is shown in Table 6.

Despite the return flows indicated in Table 6, not all water removed from the river for irrigation returns to the river via surface flow. According to Gégo and Johnson (1996), in some cases "canals divide into laterals that further divide into numerous ditches that apparently do not return to the river." Furthermore, irrigation return flows which benefit the lower Teton River "mostly originate from canals diverting water from the Falls River and the Henry's Fork." The Crosscut Canal, constructed in the 1930s, diverts water from the Henry's Fork and delivers it to Falls River Canal and the Teton River a few miles downstream of the Teton Dam site, increasing the amount of water available in the lower Teton Basin (Gégo and Johnson 1996, IWRB 1992). The average volume of water diverted from the lower Teton River for water years 1983 through 1986 was 292,022 acre-feet (IWRB 1992).

A water budget for the diversions and return flows in the Teton Subbasin upstream of the Teton Dam site has apparently not been prepared. A more thorough and precise survey of the Teton Valley diversions is expected to be made by Idaho Department of Water Resources (IDWR) adjudication staff when they review the water right claims in the area, which is currently scheduled for the year 2003 (Olenichak 2000).

Table 6. **Irrigation diversions, return flows, and supplemental flows in the lower Teton Subbasin (after Gégo and Johnson 1996 and Olenichak 2000).**

Segment of River	Diversions	Return or Supplemental Flows
Central Teton River	Wilford Irrigation and Manufacturing Company Canal	Cross Cut Canal delivers water to the Teton River from the Henry's Fork
	Teton Irrigation, Teton Generation Station, and Siddoway Ditch	Exchange wells
	Pioneer Ditch	
	Steward Ditch	
North Fork Teton River	Pincock-Byington Ditch	Farmer's Friend Canal
	Teton Island Feeder, Salem Irrigation, and Teton Island Canal	Exchange wells
	North Salem Agriculture and Milling Canal	Salem Union Company
	Roxana Canal	
	Island Ward Canal	Island Ward Canal, which diverts from the North Fork, receives return flows from the Consolidated Farmers Canal
	Saurey-Sommers Canal	
South Fork Teton River	Pincock-Garner Canal Company	Exchange wells and Teton Generation Station
	McCormick Ditch (abandoned 1999)	Moody Creek, which discharges to the South Fork via a constructed channel, receives return flows from the Teton Canal, East Teton Canal, and Enterprise Canal, though Moody Creek is diverted to the Woodmansee-Johnson Canal
	Bigler Slough Ditch	Teton Island Canal, which diverts water from the North Fork, also discharges to the South Fork
	Woodmansee-Johnson Canal	
	City of Rexburg Canal	
	Rexburg Irrigation Canal	

In the late 1960s and early 1970s, the U.S. Department of Agriculture (USDA) provided funding and NRCS technical support to replace some surface irrigation ditches in the Teton Valley with pipelines. Pipelines were installed near or below the Caribou-Targhee National Forest boundary on Trail, Game, Fox, Packsaddle, and Patterson Creeks to reduce losses of irrigation water due to infiltration. As much as 30% of the water diverted through irrigation ditches was estimated to have filtered through the subsoil prior to installation of the pipelines (Ray 1999). Although diversion of water through pipelines altered surface and subsurface flow, the practice also eliminated miles of ditches that had previously served as sources of sediment. The Packsaddle pipeline is in need of maintenance and repair, and failure of the pipeline will require a return to the use of irrigation ditches (Lerwill 2000). The current condition of all pipelines in the subbasin needs to be evaluated, and possible sources of funding for repair and maintenance identified. Preferably, this evaluation would also include an analysis of the effects of pipeline diversions on the hydrology and wetlands of the Teton Valley, and consider alternatives that would address values other than delivery of irrigation water and sediment reduction.

Three dams exist on the Teton River, though only one is currently maintained. The Felt Dam Hydroelectric Project is located approximately one-half mile above the mouth of Badger Creek. The dam was constructed in 1921, and is now owned by the Fall River Rural Electric Cooperative (FRREC). By the 1980s, the reservoir behind Felt Dam had filled with sediment, according to the Federal Energy Regulatory Commission (FRREC 1982).

In the early 1980s, Bonneville Pacific Corporation of Salt Lake City entered into a 35-year lease with FRREC to upgrade and operate the Felt Dam Hydrolectric Project. The powerhouse was relocated to maximize hydraulic head, transmission lines were relocated, and the access road was widened. Because of violations of the CWA during construction, Bonneville Pacific was required to complete on- and off-site environmental mitigation projects.

Because of the influence of Felt Dam on flow within the Teton River, the Henry's Fork Water Quality Subcommittee recommended that the segment of the Teton River identified in Idaho's Water Quality Standards as "US-20, Teton River - Spring Creek to Badger Creek" be revised. A new segment of the river bounded by the normal elevation of Felt Dam pool (5530 feet) and the Felt Dam outlet was added, and the boundaries of upstream and downstream segments were modified correspondingly (Appendix D).

Other dam sites in the subbasin include Fox Creek near the forest boundary, Webster Dam on Moody Creek, the Linderman Dam in Teton Canyon near the confluence of Milk Creek, and the Teton Dam site. Fox Creek Dam has been in place at least 20 years and was apparently built to create a settling pond for a quarry operation. The concrete dam is approximately eight feet high, but the area behind it has filled to a depth of approximately 6 feet. Webster Dam was built around 1900 and its reservoir has since filled with sediment. It now resembles a wet meadow and the dam is a barrier to upstream fish passage. The Linderman Dam was built in the 1950s for irrigation purposes but is no longer functional. Remnants of the dam remain in the Teton River channel, but the dam is not a barrier to fish movement. The Teton Dam was completed in 1975 and collapsed in 1976. On the day the dam collapsed, a discharge of 1.7 million cfs was estimated for the Teton River at the St. Anthony gage. Although a major portion of the earth-filled dam remains, it is not a barrier to fish migration.

The USGS identifies the Teton Subbasin as hydrologic unit code (HUC) 17040204. This eight-digit code indicates the location of the subbasin within successively smaller hydrologic units (USGS 1998). The Teton River cataloging unit is located in the Pacific Northwest region (HUC 17), Upper Columbia subregion (HUC 1704), and Upper Snake accounting unit (HUC 170402). It is bounded in Idaho on the north by the Lower Henry's Fork cataloging unit (HUC 17040203), on the southwest by the Idaho Falls cataloging unit (17040201) and on the southeast by the Palisades cataloging unit (HUC 17040104) (Figures 3, 6, and 7).

As shown in Table 7, the Teton Subbasin contains 44 waterbody units, designated US-1 through US-44 to signify that the units are located in the Upper Snake River Basin. Although multiple stream segments may exist within a unit, the designated beneficial uses for each segment within a unit are identical. As previously mentioned, when the proposed waterbody units were published, the Water Quality Subcommittee of the Henry's Fork Watershed Council reviewed the lists and associated waterbody identification maps for the entire Henry's Fork basin, and made extensive recommendations to DEQ regarding revision of the boundaries. As explained in the *Administrator's Response to Oral and Written Comments on Docket #16-0102-9704* (DEQ 1999a), the only recommendations that were incorporated in the final version of the proposed rule were changes in boundary nomenclature and use designations. The recommendations of the council incorporate knowledge of streamflow that cannot be determined from a 1:100,000-scale hydrography and are therefore included in this assessment (Appendix D) as a reference for designation of beneficial uses and TMDL implementation planning.

Soils

Soils in the Teton Subbasin have been well characterized. Soils occurring on the Caribou-Targhee National Forest are described in the ecological unit inventory prepared by Bowerman *et al*. (1999), and soils occurring on privately owned land are described in surveys published by the USDA Soil Conservation Service (now NRCS). A survey of the Teton County area was issued in 1969 (USDA 1969), a survey of the Madison County area was issued in 1981 (USDA 1981), and a survey of the western part of Fremont County was issued in 1993 (USDA 1993). The Teton County area soil survey is currently being digitized to enable development of geographical information system (GIS) coverages. Digitization is being completed by the Idaho National Engineering and Environmental Laboratory (INEEL) and the Idaho State University GIS Center with support from Teton County, Teton Soil Conservation District (TSCD), Bureau of Land Management (BLM), and the NRCS. Completion of this project will facilitate detailed land use planning and management.

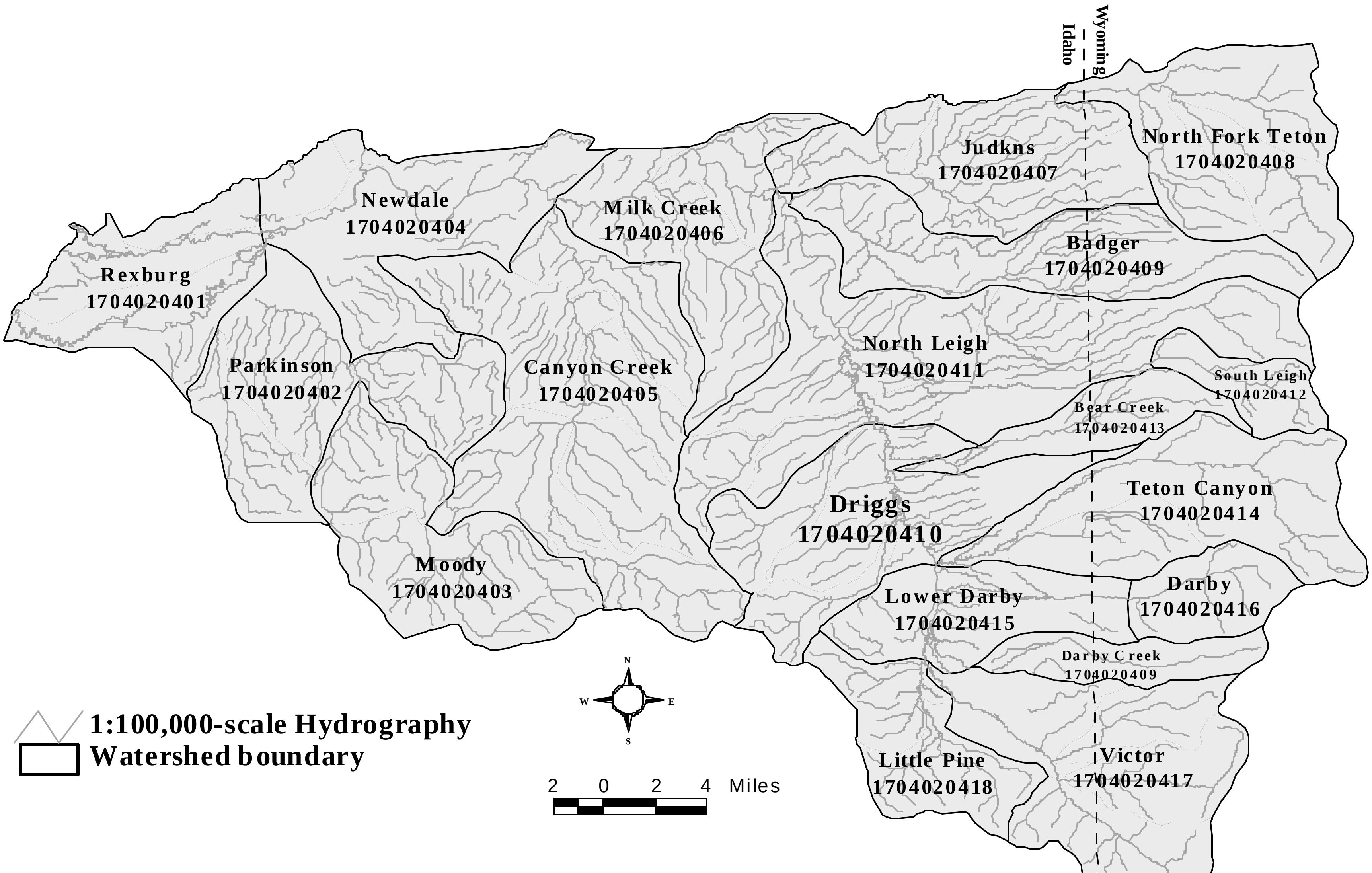


Figure 6. Names and hydrologic unit codes (HUCs) of watersheds in the Teton subbasin. The waterbodies shown appear on maps scaled 1:100,000, and include intermittent streams.

Label	Subwatershed	Acres
A	Badger Creek	
B	Badger Creek	40,474
C	Teton River	
1	Rammel Hollow	7,487
2	Spring Creek	27,962
3	South Leigh Creek	20,551
4	Packsaddle Creek	7,008
5	Dry Hollow	2,587
6	Horseshoe Creek	13,899
7	No Name	4,085
8	Dry Creek	29,158
9	Teton Creek	33,260
10	Spring Creek II	14,608
11	Twin Creeks	5,080
12	Mahogany Creek	7,023
13	Teton River	6,487
14	Foster Slough	3,548
15	Darby Creek	19,780
16	Bouquet Creek	3 ,301
17	Patterson Creek	4,903
18	Trail Creek	28,397
19	Fox Creek	15,429
20	Game Creek	8,604
21	Moose Creek	14,272
22	Drake Creek	2,661
23	Little Pine Creek	7,739
24	Warm Creek	7,739

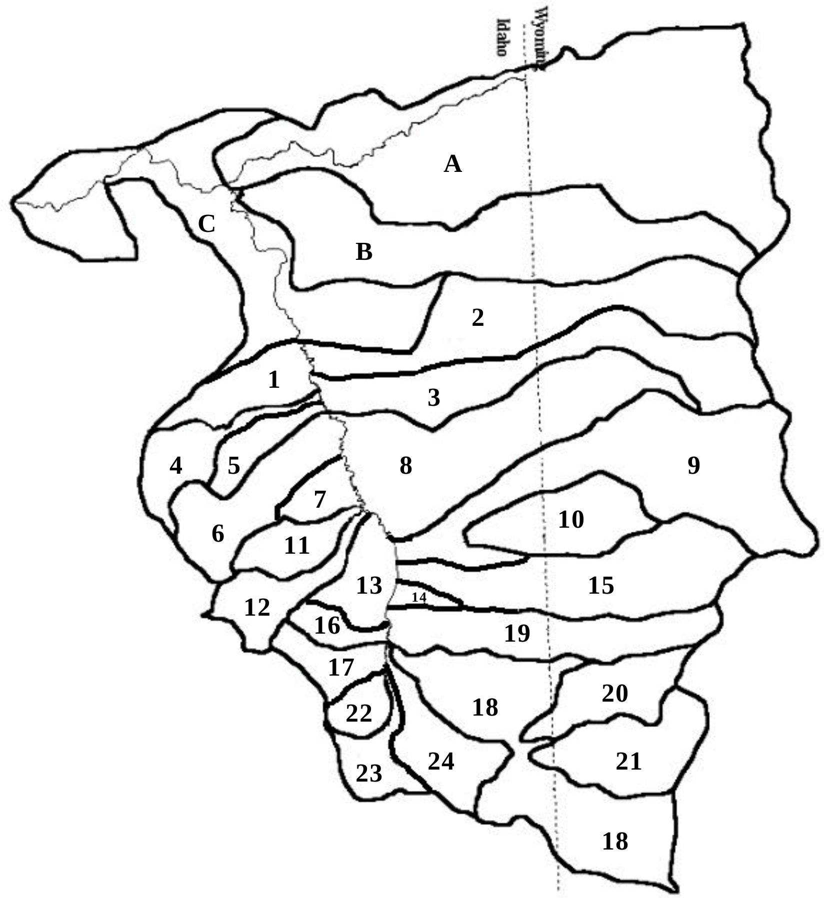


Figure 7. Subwatershed boundaries in the upper Teton River subbasin (after TSCD 1990 and USDA 1992).

Table 7. Excerpt of *IDAPA 58.01.02 - Water Quality Standards and Wastewater Treatment Requirements*, showing the boundaries of waterbody units listed for the Teton Subbasin. The prefix "US" indicates that the unit is located in the Upper Snake River Basin.

Unit	Waters
US-1	South Fork Teton River - Teton River Forks to Henry's Fork
US-2	North Fork Teton River - Teton River Forks to Henry's Fork
US-3	Teton River - Teton Dam to Teton River Forks
US-4	Teton River - Canyon Creek to Teton Dam
US-5	Moody Creek - Long Hollow Creek to mouth
US-6	Moody Creek - confluence of North and South Fork Moody Creeks to Long Hollow Creek
US-7	South Fork Moody Creek - source to mouth
US-8	North Fork Moody Creek - source to mouth
US-9	Long Hollow Creek - source to mouth
US-10	Tributaries to Canyon Creek Canal - source to mouth
US-11	Canyon Creek - Crooked Creek to mouth
US-12	Canyon Creek - Warm Creek to Crooked Creek
US-13	Canyon Creek - source to Warm Creek
US-14	Calamity Creek - source to mouth
US-15	Warm Creek - source to mouth
US-16	Crooked Creek - source to mouth
US-17	Teton River - Milk Creek to Canyon Creek
US-18	Milk Creek - source to mouth
US-19	Teton River - Badger Creek to Milk Creek
US-20	Teton River - Spring Creek to Badger Creek
US-21	Teton River - Mahogany Creek to Spring Creek
US-22	Packsaddle Creek - source to mouth
US-23	Horseshoe Creek - source to mouth
US-24	Mahogany Creek - source to mouth
US-25	Teton River - Patterson Creek to Mahogany Creek
US-26	Patterson Creek - source to mouth
US-27	Teton River - source to Patterson Creek
US-28	Trail Creek - Moose Creek to mouth
US-29	Trail Creek - Idaho/Wyoming border to and including Moose Creek
US-30	Fox Creek - Idaho/Wyoming border to mouth
US-31	Darby Creek - Idaho/Wyoming border to mouth
US-32	Teton Creek - Idaho/Wyoming border to mouth
US-33	Dry Creek - source to mouth
US-34	South Leigh Creek - Idaho/Wyoming border to mouth
US-35	Spring Creek - North Leigh Creek to mouth
US-36	North Leigh Creek - Idaho/Wyoming border to mouth
US-37	Spring Creek - source to North Leigh Creek
US-38	Badger Creek - confluence of North and South Fork Badger Creeks to mouth
US-39	South Fork Badger Creek - source to mouth
US-40	North Fork Badger Creek - source to mouth
US-41	Bitch Creek - Swanner Creek to mouth
US-42	Swanner Creek - source to mouth
US-43	Horse Creek - source to mouth
US-44	Bitch Creek - source to Horse Creek

Soil surveys consist of general soil map units or soil associations that are subdivided into detailed map units. General map units are usually thousands of acres in size and delineate unique natural landscapes consisting of distinctive patterns of soils, relief, and drainage (USDA 1993). A detailed map unit may be as small as an acre in size and delineates a specific soil, soil series, or soil complex. General map units indicate the suitability of large areas for general land use; detailed map units indicate the suitability of more localized areas for specific uses such as crop production and placement of septic systems, roads, and building sites.

Soils in the Teton Subbasin are categorized into ten general map units in Madison County, eight units in Teton County, and three units in Fremont County. But because these map units were identified over a 25-year period using techniques and terminology unique to each county, they cannot be linked to create a map of the entire subbasin. The NRCS has circumvented this problem by compiling soil survey data and generalizing it statistically to a scale of 1:250,000 (USDA 1995). The resulting State Soil Geographic (STATSGO) database is one of three maintained by the NRCS, and is designed as a tool for resource planning, management, and monitoring at the multi-county, state, and regional levels.

Soils in the Teton Subbasin in Idaho are categorized into 15 STATSGO map units (Figure 8 and Table 8). More than half the soils in the subbasin are classified as silty loams or loams containing more than 45% silt-sized particles. According to the USDA soil particle classification system, silt-sized particles are greater than 0.002 mm and less than 0.05 mm in diameter (Brady and Weil 1996). Relative to very clayey or very sandy soils, silty loams are well-suited to cultivation but are easily eroded by wind and water. In the Teton Valley, upland soils (ID129 and ID130) are a combination of silt loams, gravelly loams, and cobbly loams, whereas lowland soils bordering the river (ID131) are a combination of silty clay loams and gravelly loams. Silty clay loams and gravelly loams also occur along the northwestern border of the subbasin in the floodplains of the North and South Fork Teton and Henry's Fork Rivers (ID122 and ID123). The increased proportion of clay in the lowland soils increases water-holding capacity, reduces aeration and drainage, and reduces the potential for erosion.

The susceptibility of soil to accelerated erosion is a function of the following six factors:

R = climatic erosivity (rainfall and runoff)
K = soil erodibility
L = slope length
S = slope gradient or steepness
C = cover and management
P = erosion-control practice

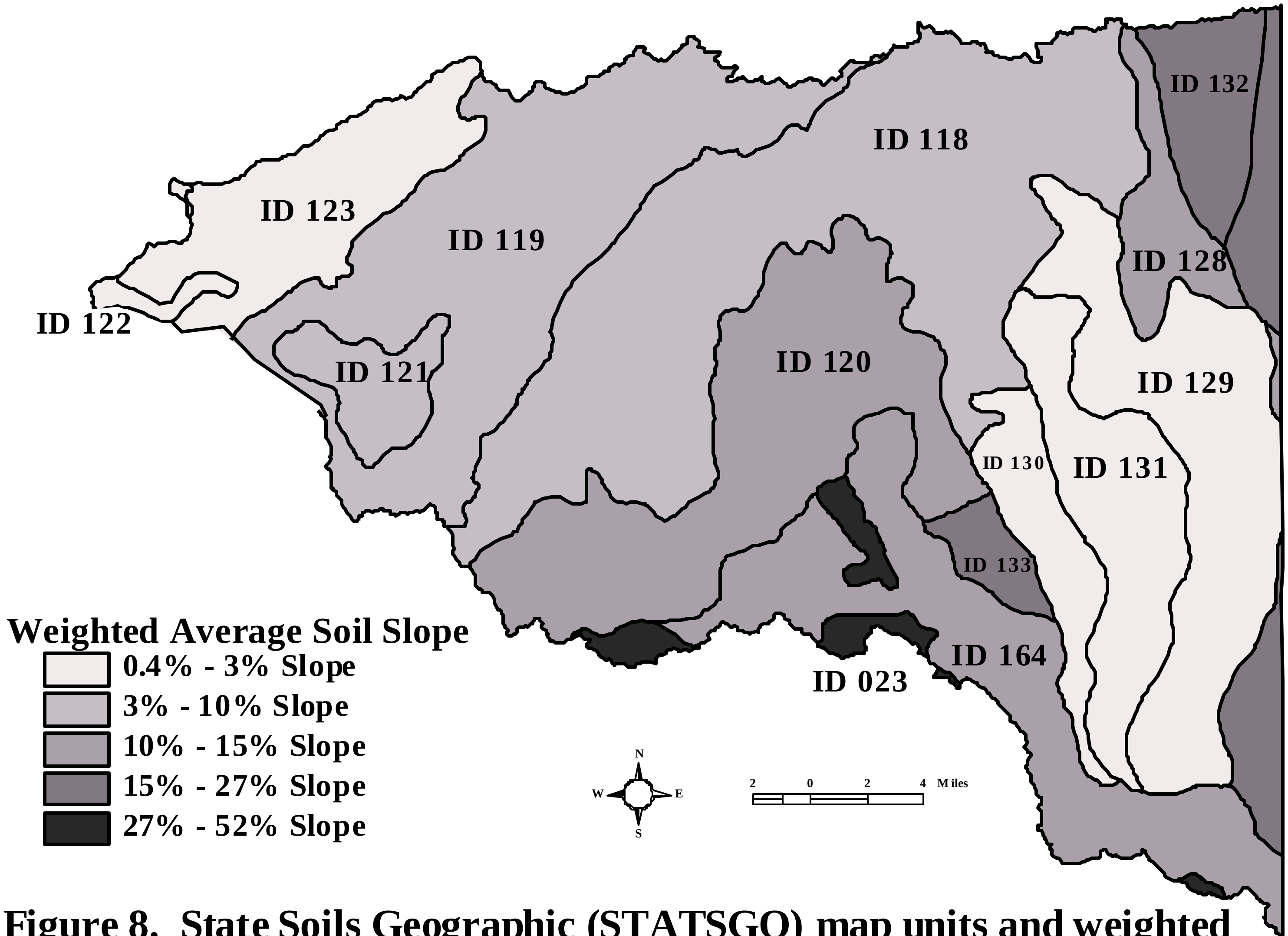


Figure 8. State Soils Geographic (STATSGO) map units and weighted average soil slopes.

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Table 8. Summary of STATSGO soil information for the Teton Subbasin[1].

Map Unit	Soil Association Name and Description[2]	Area (acres)	Area (mi^2)	Average Values For: Slope (%)	Depth (inch)	K Factor[3]
ID118	*Ririe-Lantonia-Tetonia*: Deep to very deep, well-drained silt loam soils on dissected plateaus; formed in wind laid materials; native vegetation includes bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and sagebrush	117,394	183	6-20	12	0.39
ID119	*Rexburg-Ririe-Tetonia*: Deep, well-drained silt loam soils on dissected plateaus; formed in wind laid materials; native vegetation includes bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and sagebrush	77,366	121	5-10	10	0.43
ID120	*Karlan-Greys-Turnerville*: Well-drained silt loam soils underlain by rhyolite or rhyolite tuff bedrock; formed in loess with residuum from bedrock (*Karlan*) or very deep loess (*Greys* and *Turnerville*); native vegetation includes grass (*Karlan*), aspen, chokecherry, wild rose and pinegrass (*Greys*), or lodgepole pine, Douglas-fir, and pinegrass (*Turnerville*)	65,493	102	10-23	12	0.40
ID129	*Driggs-Tetonia-Badgerton:* Level to gently sloping, well-drained soils that formed in alluvium and loess over gravel and sand; native vegetation includes bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and sagebrush	52,576	82	2-5	8	0.34
ID164	*Judkins-Stringam-Targhee*: Well-drained, extremely stony loam soils formed in rhyolite bedrock and small amount of loess; native vegetation includes lodgepole pine, Douglas-fir, and pinegrass (*Judkins*)	50,773	79	4-22	8	0.31
ID123	*Withers-Annis-Blackfoot*: Deep, somewhat poorly drained silty clay loams and silt loams formed in alluvium on river terraces and floodplains	32,042	50	0-1	8	0.33
ID131	*Zohner-Furniss-Foxcreek*: Poorly drained silty clay loams and gravelly loams formed in alluvium derived from limestone, granite, quartzite, gneiss, and sandstone; native vegetation includes sedges, ruches, shrubby cinquefoil, willows, and other water-tolerant plants	30,602	48	0.2-2	11	0.23

According to the universal soil-loss equation and revised universal soil-loss equation, the product of these factors is equivalent to soil loss. Soil erodibility, or K factor, is a relative index of the susceptibility of bare, cultivated soil to particle detachment and transport by rainfall. It is an inherent property of soil that is related to its infiltration capacity and structural stability. Soils with high infiltration capacities and good structural stability are not easily eroded and have low K factors less than 0.2. Soils with intermediate infiltration capacities and moderate structural stability are moderately erodible and have K factors from 0.2 to 0.3. Soils with low infiltration capacities and poor structural stability are highly erodible and have K factors ranging from more than 0.3 to approximately 0.6 (Brady and Weil 1996). The average K factors shown in Figure 9 indicate that most soils in the Teton Subbasin are moderately to highly erodible.

Slope gradient, along with slope length, are topographic features that also influence erosion potential. Soils with steeper slopes are generally more susceptible to erosion though the complexity of the slope and a soil's susceptibility to rill and interrill erosion can significantly alter erosion potential. The map units with the highest average slope values are ID132, which corresponds to the upper Bitch Creek and upper Badger Creek watersheds, and ID133, which corresponds to the upper Horseshoe Creek and upper Mahogany Creek watersheds (Table 8 and Figure 9).

Soil depth, which is also shown in Table 8, is one of several factors that determine the tolerable soil loss, or T-value, of a soil. T-values have been developed by the NRCS for all cultivated soils in the United States, and range from approximately 2 tons/acre to 5 tons/acre. The T-value is an informed estimate of the maximum amount of soil that can be lost annually from cultivated land by wind and water erosion without degrading the long-term productivity of the soil. Erosion-control management plans prepared by farmers with assistance from the NRCS generally incorporate T-values as the planning level for erosion rates. In the Teton Subbasin, T-values range from 2 tons/acre for shallow soils to 5 tons/acre for deep soils. This latter value is equivalent to the amount of soil covering a one-acre cultivated field to a depth of 1/32 inch.